creating a notably dark and heavily shaded environment, at the edge of which the collecting was done. This certainly accounts for the relative abundance of *Panthea furcilla,* a pine feeder.

It is greatly to be hoped that many other collectors will make consistent ''total counts'' of all species showing any appreciable melanism, and record the results. Only in this way can a body of knowledge be built up that will serve as a basis of comparison for other workers in our rapidly changing environment.

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SCENT-APPARATUS MORPHOLOGY OF *LEPTOCORISA COSTALIS* H. S. (HETEROPTERA: COREIDAE), WITH COMMENTS ON GLANDULAR SECRETIONS IN HETEROPTERA

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Abstract The anatomy and the mode of action of the scent-apparatus of *Leptocorisa costalis* H. S. is described and discussed. Recent studies on the chemistry of the glandular secretion have thrown some light on the feeding habits, sexual activity and probably on the phyogenetic relationship of various families in Heteroptera.

Leptocorisa costalis H. S. is found in rice fields and wild grass in India. Although Akbar (1957–58) studied the morphology and the life-history of *Leptocorisa varicornis* F. in detail, he omitted consideration of its scent-apparatus. As far as is known, no account of the scent-apparatus of *Leptocorisa* is available. The present study is aimed at filling that gap.

The adults were collected in August/September, 1954 on wild grass in the Ayurvedic Gardens on the campus of Banaras Hindu University, India. Dissections were made on fresh specimens and materials preserved in 70 per cent alcohol. All drawings were made with the aid of an ocular grid and are not to the same scale.

Scent-apparatus (Fig. 1) On opening the body cavity and removing the overlying viscera, the scent-apparatus is visible below the digestive tract, lying in the region of the metathorax. It consists of a pair of compact glands, a median reservoir, a vestibule and an ostiole or external orifice.

The glands The glands are compact masses of convoluted tubes which

ramify abundantly and show almost racemose branching when separated. Each gland lies laterally, more or less covering the cephalic end of the reservoir and is in close contact with its counterpart of the opposite side. The glandular tissue is white and granular and can thus be distinguished from the fat-body, which appears as loose aggregate of cells. Each gland opens into the reservoir by means of a short, thin membranous duct.

The reservoir The reservoir is pale orange in color and appears translucent. It is an elongated sac with a transversely broadened cephalic portion, the lateral extremities of which form short tubular ducts, which are joined to the inner portion of the vestibule on each side. The membranous duct of each gland opens into the tubular duct of the reservoir. The walls of the reservoir duct are usually in close apposition. Behind the broad cephalic portion, the reservoir narrows and then expands into a tubular portion with folded lateral walls. These folds give a wrinkled appearance to the reservoir when it is deplete. When full of secretion, the surface of the reservoir presents a smooth outline. Incorporated in the wall of the reservoir are grooves and ridges which give it a furrowed appearance. An accessory gland is not present in the reservoir. The posterior part of the reservoir extending into the abdomen, rests on a transverse ridge formed by the junction of the metathorax and the first abdominal segment. The space posterior to the ridge and between the sac and the ventral abdominal wall is filled with adipose tissue.

The vestibule (Figs. 1 and 2) The lateral ducts of the reservoir lead into a barrel-shaped chamber-like duct, called the vestibule. This duct is highly sclerotized, with the internal surface furrowed or grooved along its longitudinal axis. Distally, the lateral sides of the vestibule terminate into two curved ridges to which is fused a crescent-shaped ridge with inwardly curved ends. The vestibule opens to the exterior by means of an ostiole which is roughly ovoid and appears externally as an oblique opening partially overlapped along its length by a curved metasternal flap (Fig. 3). This flap is beset externally with setae and presents a rugose surface. The ostiolar opening is located between the episternum and the lateral part of the basisternum of the metasternum. The area of the body wall around the ostiole is slightly raised into a ridge. Externally, the area of the metasternum around the vestibule is sculptured to provide a rough surface for the evaporation of the secretion.

The valvular apparatus (Figs. 1 and 2) It consists of a folded valve, a
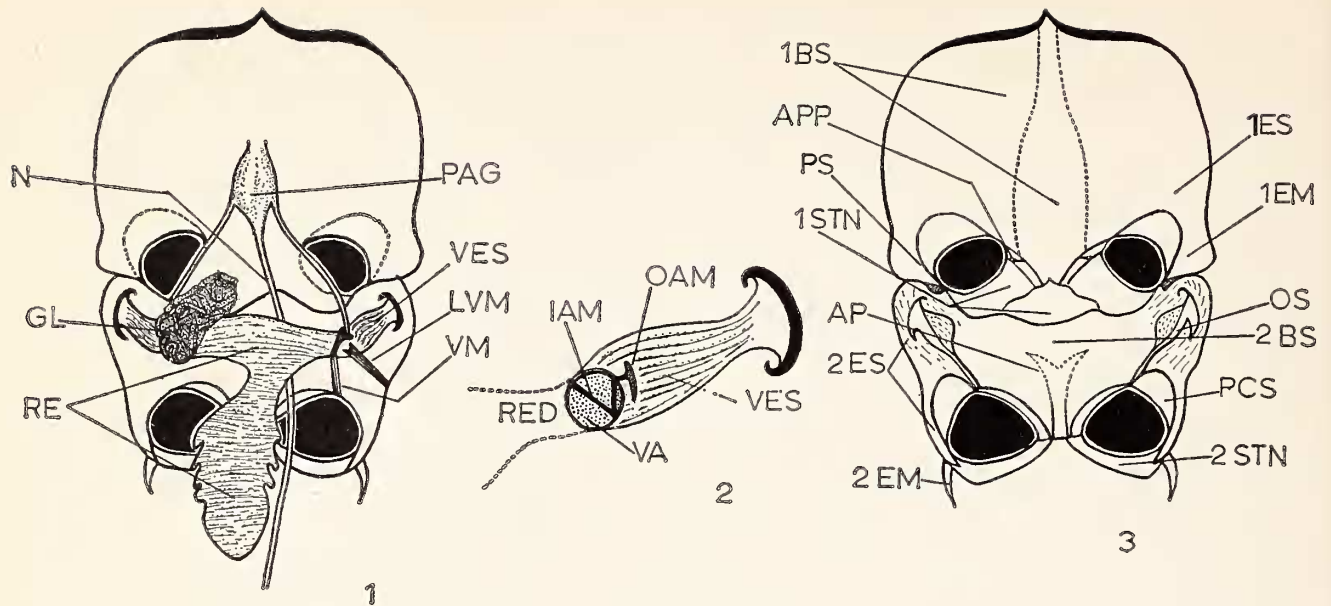
Fig. 1—Internal view of the pterothroax showing the scent-apparatus.

Fig. 2—Reservoir duct, valve, inner and outer arms and the vestibule.

Fig. 3—Ventral view of pterothorax showing external orifice of scent-apparatus.

Abbreviations used in figures

AP	apophyseal apodeme
APP	apophyseal pits
1 BS	basisternum of mesothorax
2 BS	basisternum of metathorax
1 EM	mesepimeron
2 EM	metepimeron
1 ES	mesepisternum
2 ES	metepisternum
GL	gland
IAM	inner arm
LVM	latero-ventral or larger muscle
N	ventral nerve cord
OAM	outer arm
OS	ostiole or external orifice
PAG	pterothoraco-abdominal ganglion
PCS	precoxal shelf
PS	pleural sulcus
RE	reservior
RED	reservoir duct
1 STN	mesosternellum
2 STN	metasternellum
VA	valve
VES	vestibule
VM	ventral or smaller muscle

pair of chitinous arms and a pair of muscles. The valve is located at the
junction of the duct of the reservoir and the inner portion of the vestibule.
It is fused with the inner rim of the vestibule except at a point antero-
ventrally where the reservoir duct opens into the vestibule. The valve is
folded on itself, the smaller fold being provided with a V-shaped inner arm.
The upper limb of this arm is in association with an outer arm which projects
from the upper edge of the inner rim of the vestibule and extends antero-
posteriorly. The junction of the two limbs of the V-shaped arm is in close
association with the junction of the rim of the duct of the reservoir and the
vestibule.

The valvular apparatus is operated by a pair of muscles on each side.
The smaller ventral muscle extends from the anterior rim of the metacoxal
cavity to the posteriorly-directed limb of the outer arm. The larger latero-
ventral muscle originates on the pleuron close to the lateral margin of the
third phragma and has a double attachment with the scent-apparatus: the
anterior head is attached on the margin of the duct of the reservoir and the
posterior head on the region where the base of the V-shaped arm is joined
to the junction of the rims of the reservoir duct and the vestibule.

Mode of action The flow of the secretion from the glands to the reservoir
is probably effected by the cumulative pressure in the main ducts of the
glands.The contraction of the smaller muscle pulls the outer arm poste-
riorly which in turn exerts a pull on the upper limb of the V-shaped arm.
Simultaneously, the contraction of the larger muscle results in double
action: its anterior head separating the apposed walls of the reservoir duct
and thus opening it; at the same time exerting a pull on the junction of the
V-shaped inner arm, causing contraction of the valve, opening the valvular
opening and ejecting the fluid to the outside.

Tracheation and nerve supply The glands show a far richer tracheal
supply than does the reservoir. A nerve from the fused pterothoraco-ab-
dominal ganglion runs postero-laterally and terminates at the base of the
outer arm on each side. It probably innervates the smaller valvular muscle
attached to the outer arm. No nerve connection was observed to the larger
muscle, the reservoir and the glands.

Discussion The studies of Moody (1930) and Brindley (1930) and the
present study indicate that the accessory gland is absent in the Coreidae.
The Coreidae also seem to possess an oval reservoir. Gupta (1961) sug-
gested that, with regard to the general form of the reservoir and the absence
of the accessory gland, the Coreidae resemble Miridae and Tingidae. It
has been stated that the flow of the secretion from the glands into the
reservoir is probably due to the cumulative pressure in the main duct of

the gland. Johansson (1957) has demonstrated that in *Oncopeltus* removal of the reservoir results in increased size of the gland. He thus inferred that there is no passive flow of the secretion from the glands into the reservoir. Probably the elasticity of the reservoir provides an occlusive force which draws in the secretion from the gland. Thus, in the absence of the reservoir, the secretion remains in the main duct of the gland because the cumulative pressure in the main duct is insufficient to expel the fluid into the reservoir. Henrici (1940) in *Melanocoryphus* and Johansson (1957) in *Oncopeltus* reported that the ventral muscle is responsible for the active opening of the passage from the tubular glands to the reservoir. While it may be true in the two lygaeids they studied, it is not so in *L. costalis*, in which the function of the ventral muscle seems to be primarily to open the passage from the reservoir to the vestibule, since it is attached to the outer arm which in turn is associated with the valvular mechanism. Moody (1930) reported the same in *Anasa tristis* (De Geer). Johansson (1957) failed to demonstrate that the removal of the ventral muscle in *Oncopeltus* actually results in an empty reservoir, which should be the case if the ventral muscle actually opens the passage. This adds further weight to my suggestion that the flow of the secretion from the glands to the reservoir is due to both the cumulative pressure in the main duct of the gland and the occlusive force of the reservoir. The role of the latero-ventral muscle in opening the passage from the reservoir to the vestibule and thus to the exterior has been reported by Moody (1930), Henrici (1940), Johansson (1957) and is confirmed by the present study. The double attachment of this muscle has been reported by Malouf (1932), Akbar (1957) and Johansson (1957). Probably in *L. costalis* this muscle may also be responsible in opening the passage from the glands into the reservoir since its anterior head is attached on the lateral duct of the reservoir.

Different authors have reported nerve connections to different parts of the scent-apparatus in different insects. For example, Murray (1914) and Puri (1924) found nerve supply to accessory glands. Moody (1930) and Johansson (1957) reported innervation of the muscles which operate the valvular mechansim. In *Leptocorisa*, however, only the outer arms seem to be innervated by a nerve. Akbar (1957) did not mention any nerves going to the latero-ventral or the ventral muscle. No one has so far emphasized the importance of nerve connection to the scent-apparatus. It is generally agreed that one of the probable functions of the scent-apparatus is defense. When prodded or disturbed, the insects eject the fluid immediately, indicating that the action is triggered by nerve stimuli. Presumably, the scent-apparatus in these insects must be provided with some kind of nerve connection.

The force necessary for the ejection of the fluid has been attributed to the contraction of thoracic muscles (Moody, 1930), to the elasticity of the res-

ervoir and the increased pressure in the body cavity (Betten, 1943; Johansson, 1957) and to the coxal pressure (Blum et al., 1961). In *Leptocorisa*, and probably in other insects as well, the main force for ejection is supplied by the elasticity of the reservoir. This agrees with Moody's (1930) finding in *Anasa tristis*, that after the first ejection the bugs were able to eject very small quantities after only severe prodding or injury. It is thus likely that the elasticity of the reservoir is primarily responsible for ejection and that the thoracic muscles and the internal pressure play a minor role, if at all, in the process.

The presence of a sculptured evaporative area on the sternum has been found in many bugs and has been reported by Moody (1930), Henrici (1940), Johansson (1957) and Froeschner (1960). In *Leptocorisa* also the vestibule and the surrounding area on the sternum are sculptured. That such an area is of great importance cannot be overemphasized.

The works of Blum et al. (1960), Blum (1961), Roth (1961) and Waterhouse et al. (1961) record detailed chemical analyses of the odoriferous secretion in the Pentatomidae, Coreidae and Cydnidae. According to Waterhouse et al. (1961), the characteristic odor in the pentatomids is due to carbonyl compounds whereas in the two coreids it is due to non-carbonyl compounds (possibly esters). It is evident that the perceptible odor of the odoriferous secretion in different families cannot be attributed to a single chemical component. Blum et al. (1960a) reported a similarity in the gross chemistry of the secretion of the three pentatomids they studied. Waterhouse et al. (1961) also found hex-2-enal in all the three pentatomids and n-hexanal in the two coreids they studied. However, Blum et al. (1960b) reported that each insect has its own characteristic odor. For example, they found 2-hexanal in *Brochymena* but 2-heptanal in *Oebalus* although both are pentatomids. Waterhouse et al. (1961) reported in Coreidae the existence of different materials which give characteristically different odors. This specificity may have some taxonomic value.

My suggestion (Gupta, 1961) that a detailed chemical analysis of the odoriferous secretion might indicate some relationship with the feeding habits, sexual activity and the phylogeny of various insects has been shown proven by Blum et al. (1960) and Waterhouse et al. (1961). The latter have shown that in the bronze orange bug, *Rhoecocoris sulciventris* (Stål), which lives on citrus, octa-2-enal is present in the secretion, which is interesting in view of the fact that n-octanal is found in orange oil (Guenther, 1949). There is still no direct evidence for the sexual role of the secretion. However, there is indirect evidence from the work of Waterhouse et al. (1961) for such a function. They found hex-2-enal in the three pentatomids they studied and Butenandt and Tam (1957) have reported a related substance trans-hexa-2-enal-1-acetate in the abdominal glands of male *Belostoma indica* Vitalis, which probably acts as sex odor. Blum (1961) in

Brochymena and Roth (1961) in *Scaptocoris* have proved that the secretion in these two insects has a defensive purpose. Roth has also mentioned that the vapors of the secretion of *Scaptocoris* has a fungicidal action against *Fusarium oxysporum f cubense* (F.E.S) Sny. and Hans. A comparative chemical study of the odoriferous secretion in different families of the Heteroptera is highly desirable.

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ISOTOPES TO ESTIMATE COLONY SIZE OF *FORMICA CINEREA* MAYR (HYMENOPTERA: FORMICIDAE)

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Abstract Ants taken from a mound were dipped in 100 ml. of water containing 0.1–0.2 millicuries of Au^{198}, I^{131} and P^{32} and then returned to the mound. After 1–3 days ants in a recapture sample were scanned singly with an end window Geiger-Muller tube to determine radioactive distintegration per minute. The colony size was estimated by the Lincoln Index. After preliminary trials, I^{131} was not used because of ant mortality, and Au^{198} because of its short half-life. A satisfactory method of using P^{32} was not developed, largely because of contamination between treated and non-treated ants, and the variable counts given by ants in the recapture sample. Experiments with dipping time, radioisotope concentrations and use of spreader-sticker additives did not materially improve the method. The variability in tagging was related to the difference in sizes of the worker ants.

Formica cinerea Mayr[2] builds conspicuous mounds on the prairies and wet meadows of southern Wisconsin. The ant mounds are the dominant feature of a prairie remnant existing along a railroad right-of-way near Platteville in southwestern Wisconsin. All stages of colony development are present, as evidenced by various sizes of mounds that range up to three feet in diameter and one foot high. The high density of colonies is indicated by a total of 160 mounds in a 1×1500 meter transect.

Studies on the ecology of *F. cinerea* have been conducted at Platteville since 1956. Quantitative population data have been obtained by digging and counting the individuals in a colony. This method is laborious, and it is uncertain whether all individuals are excavated, as some channels penetrate deeply in the well-drained soil. One objective of the research was

[2] Det. by Dr. W. L. Brown, Jr. Wisconsin variant would be named *F. cinerea montana* Emery, according to Gregg (1953).